Short Communication

Prelaunch Calibration of the NOAA-11 AVHRR Visible and Near IR Channels

Peter Abel

NOAA, National Environmental Satellite, Data, and Information Service, Satellite Research Laboratory, Washington, DC

The prelaunch radiometric sensitivities of Channels 1 and 2 of the NOAA-11 Advanced Very High Resolution Radiometer (AVHRR) were measured by the manufacturer, ITT, in late 1981 and in April 1988, and the satellite was launched on 24 September 1988. The results are presented here to make them more generally accessible, to inform data users of changes in the previously published results (NOAA, 1988), and to indicate their precision.

The notation largely follows that of Price (1987; 1988a, b) for NOAA 6–10. Let $\phi(\lambda)$ denote the spectral response function of a particular AVHRR channel at wavelength λ, normalized to a maximum *amplitude* of unity. The equivalent width of the spectral response can then be written as

$$w = \int_{\lambda_1}^{\lambda_2} \phi(\lambda)\, d\lambda, \tag{1}$$

where λ_1 and λ_2 represent the wavelengths bounding nonzero ϕ.

The observed radiance in units of W/(m^2 sr μm) is expressed as

$$R = \alpha C + \beta = \alpha(C - C_o), \tag{2}$$

where α and β are calculated from data measured by the instrument manufacturer in preflight tests, C is the digital count level at the output of the AVHRR, and C_o represents the count level measured when the instrument is observing space.

The count level C_o is measured 10 times for each channel during each rotation of the scan mirror (167 ms), and this information is available in the digital data. For this reason the form $R = \alpha(C - C_o)$ is preferred, because it includes only one coefficient (rather than two) from the prelaunch calibration.

The primary calibration of AVHRR Channels 1 and 2 is usually expressed in terms of an effective albedo A, where 100% albedo corresponds to the channel radiance S of a perfectly reflecting Lambertian surface illuminated at normal incidence by a solar irradiance $F(\lambda)$. In the calculations here, $F(\lambda)$ is taken from running averages of Neckel and Labs (1984) data. Then,

$$S = [1/(\pi w)] \int_{\lambda_1}^{\lambda_2} \phi(\lambda) F(\lambda)\, d\lambda. \tag{3}$$

Address correspondence to Dr. Peter Abel, NOAA/NESDIS/ORA, WWB Rm. 711-G, Washington, DC 20233.
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Table 1

A. Results calculated from ITT 1988 AVHRR data and 1987 integrating sphere source data (NOAA, 1988)

Channel	λe (μm)	w (μm)	S	α	β	γ	δ
1	0.635	0.113	518.7	0.470	−20.8	0.0906	−3.73
2	0.831	0.229	335.2	0.277	−12.6	0.0827	−3.39

B. Results calculated from ITT 1981 AVHRR data and 1978 integrating sphere calibration data

Channel	λe	w	S	α	γ	C_o[a]
1	0.635	0.113	518.6	0.524	0.101	40
2	0.832	0.229	334.8	0.316	0.097	40

C. Results calculated from ITT 1988 AVHRR data and 1989 integrating sphere calibration data

Channel	λe	w	S	α	γ	C_o[a]
1	0.635	0.113	518.6	0.490	0.095	40
2	0.832	0.229	334.8	0.301	0.090	40

[a]These values are not expected to differ from orbital values by more than a few counts, but the latter are preferable and are contained in all sensor level (*1b*) data sets.

The effective albedo in percent is defined as $A = 100(R/S)$. Using (2),

$$
\begin{aligned}
A &= 100\alpha(C - C_o)/S \\
&= \gamma C + \delta \\
&= \gamma(C - C_o),
\end{aligned}
\tag{4}
$$

where γ and δ are derivable from α, C_o, and S (and conversely).

The definition of λe in NOAA (1988) is given here for completeness. The values in Table 1 are the same as those in NOAA (1988), where

$$
\lambda e = \frac{\int_{\lambda_1}^{\lambda_2} \lambda \phi(\lambda) F(\lambda)\, d\lambda}{\int_{\lambda_1}^{\lambda_2} \phi(\lambda) F(\lambda)\, d\lambda}. \tag{5}
$$

The NOAA-11 AVHRR was calibrated in 1981 and 1988, and the integrating sphere calibration source was calibrated in 1974, 1978, 1983, 1987, and 1989. The sphere was repainted before the 1983 calibration, rendering the data inappropriate for use with the 1981 AVHRR calibration data. A detailed account of the prelaunch calibration of AVHRR is given by Rao (1987). Table 1, Entry A, gives the NOAA (1988) results. These relied on the 1988 AVHRR data and the 1987 sphere data. Entries B and C give results for the two other good matches of the dates of AVHRR and sphere calibrations (i.e., 1981 AVHRR with 1978 sphere and 1988 AVHRR with 1989 sphere).

The 1989 sphere calibration was conducted with special care because the 1987 results showed a substantial (10–16%) drop in radiance from the levels seen in 1983. The 1989 results are higher than 1987 by about 8% at all wavelengths in the range covered by the calibration (350–2000 nm), and agree well with the 1983 and earlier results at wavelengths above 900 nm. The 1987 results appear anomalous and therefore represent a poor basis for calibration of the AVHRR. Rejecting Entry A in Table 1 on this account, we are left with a choice between Entries B and C. Entry C represents the most recent prelaunch data and has the most carefully executed sphere calibration. It is important to note, however, that the slope of the 1988 AVHRR calibration response in terms of counts per number of lamps illuminated in the sphere was within 2% of the 1981 value. This suggests that the AVHRR and the sphere are probably more stable than the sphere calibration is precise, and that the difference between Entries B and C is dominated by uncertainty in the sphere calibration.

The desire to recommend values for the calibration coefficients is driven by the need for accurate interpretation of the instrumental data and the need for all users to interpret the data with the same coefficients. These needs are in conflict in the present situation. The preferred coefficients (Entry C in Table 1) have uncertainties that overlap the NOAA (1988) (Entry A) value (in Channel

1) and approach overlap in Channel 2, but the NOAA (1988) coefficients have been in use for over a year.

At this time (November 1989) the stability of NOAA-11 AVHRR Channels 1 and 2 values of α (and γ) while in orbit has not been established. In the case of the NOAA-9 AVHRR, α appears to have increased in orbit at a mean rate of approximately 6% per annum in Channel 1, and at 9% per annum in Channel 2 (Abel et al., 1988; Brest and Rossow, 1990). The NOAA-6 and NOAA-7 AVHRR channel 1 values of α showed greater stability (Staylor, 1990).

NOAA plans to hold continuing meetings on an ad hoc basis on the calibration, stability, and intercomparison of results from satellite radiometers operating at visible and near-infrared wavelengths. Those interested in participating in future meetings may contact the author at NOAA/NESDIS/ORA, Washington, DC 20233.

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